

Using the Basic "Auto-validation" Model
to Assess the Effect of Environmental Quality
on Texas Recreational Fishing Demand: Welfare Estimates

by

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ABSTRACT

In an extensive earlier paper (Cameron, 1988a) we developed a fully utility-theoretic model for the demand for recreational fishing access days, applied to a sample of 3366 Texas Gulf coast anglers. The model employs "contingent valuation" and "travel cost" data, jointly, in the process of calibrating a single utility function defined over fishing days versus all other goods and services. The theoretical specification (quadratic direct utility) and the econometric implementation will not be reproduced here. Instead, we focus specifically on the implications of an extension to this model. We employ a subset of 506 observations from the same survey for which respondents were asked to indicate their *ex post subjective* assessment of the environmental quality at the fishing site. We allow the parameters of the underlying utility function to vary systematically with the perceived level of environmental quality to assess the impact of environmental factors on the demand for access days. Treating the 10-point response scale for environmental quality (E) as a continuous variable, we find (among other results) that for the average angler improving E from one standard deviation below the mean to one standard deviation above increases the value of the fishery (measured by equivalent variation) by about \$1400 (about 50%).

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1. Introduction

In Cameron (1988a), we derived and estimated the parameters of a quadratic utility function for a trimmed sample of Texas Gulf Coast recreational fishermen. The utility function, in its simplest form, is defined over fishing access days and all other goods and services (income). The novelty of that paper is primarily its utilization of a fully utility-theoretic framework for analyzing *both* "contingent valuation" (CV) data (respondents anticipated behavior under hypothetical scenarios) and "travel cost" data (respondents' actual behavior in the consumption of access days). The latter form of data gives us a feel for the consequences of small local variations in access prices; the former provides additional information, however hypothetical, regarding more drastic changes in the consumption environment.

The earlier paper develops the basic specification and goes on to consider several extensions to that basic model: discounting the influence of the CV data in the estimation process; estimation without travel cost data (only income and consumption); and the accommodation of heterogeneous preferences. In the last category, we demonstrated that it is straightforward to adapt these models to allow for systematic variation in the preference function according to geographical or sociodemographic factors.

In this paper, we will again employ heterogeneous utility functions, but we will only be able to exploit a subset of the data. We wish to concentrate upon the potential effects of respondents' perceptions about environmental quality on their demand (valuation) of access to the recreational fishery.

Readers are referred to Cameron (1988a) for a vital preface to this research. We avoid extensive duplication in this paper by presuming readers are familiar with the findings of the earlier paper.

2. Outline of the Specification

As before, we will adopt the quadratic family of utility functions, for the same variety of reasons explained in the earlier paper. We will let U denote direct utility, Y will be income, and F will be current fishing day expenditures ("travel costs", roughly). Also, q will be the number of fishing days consumed and z ($= Y - Fq$) will denote consumption of other goods and services. We will let E denote subjective environmental quality. The quadratic direct utility function will thus take the form:

$$(1) \quad U = \beta_1 z + \beta_2 q + \beta_3 z^2/2 + \beta_4 zq + \beta_5 q^2/2,$$

where the β_j are no longer constants, but will be allowed to vary linearly with the level of E : $\beta_j^* = \beta_j + \gamma_j E$, $j=1, \dots, 5$.

3. Data

The data used for this model consist of a 506 observation subset of the 3366 observations used in the earlier paper. The data come from an in-person survey conducted by the Texas Department of Parks and Wildlife between May and November of 1987. The primary purpose of the survey is to count numbers and species of fish making up the recreational catch, but during this particular period, additional economic valuation questions were posed to respondents.

In particular, the contingent valuation question took the form: "If the total cost of all your saltwater fishing last year was _____ more, would you have quit fishing completely?" At the start of each day, interviewers randomly chose a starting value from the list \$50, \$100, \$200, \$400, \$600,

\$800, \$1000, \$1500, \$5000, and \$20,000. In addition, respondents were queried regarding actual market expenditures during the current trip: "How much will you spend on this fishing trip from when you left home until you get home?" This is as close as we can get to a measure of "travel cost."

The same basic criteria for deleting particular observations are applied in this paper as are described in Cameron (1988a). The same caveats regarding the sample also apply in this case. The sample employed in this study is smaller only because the *ex post* subjective environmental quality questions were asked of only approximately one-eighth of the full sample. This question was just one of eight rotating questions on special issues.

The precise wording of the environmental quality question was "To what extent were you able to enjoy unpolluted natural surroundings [during this fishing trip]?" Responses were given on a Likert-type scale of 1 to 10, with 10 being highest. The means and standard deviations for both the full sample of 3366 and the subset of 506 responses are given in Table 1. As can be seen, the subset is fairly representative of the larger sample.

4. Utility Parameter Estimates

To assess whether or not the preference function differs systematically with the level of environmental quality, we estimate two models. First, we re-estimate the "basic" joint model from the earlier paper using *just* the subset of 506 observations. This specification constrains the β coefficients to be identical across all levels of environmental quality. Then we generalize the model by allowing each β to be a linear function of \mathbf{E} , which involves the introduction of five new α parameters. Since the "basic" specification is a special case of the model incorporating heterogeneity, a likelihood ratio test is the appropriate measure of whether \mathbf{E} "matters." Results for the two models are presented in Table 2. The LR test statistic is

Table 1

Descriptive Statistics for Full Sample and "Environmental" Subset

Variable	Description	Full Sample (n = 3366)	Subset (n = 506)
Y	median household income for respondent's 5-digit zip code (in \$10,000) (1980 Census scaled to reflect 1987 income; factor = 1.699)	3.1725 (0.9995)	3.1681 (1.0134)
F	current trip market expenditures, assumed to be average for all trips (in \$10,000)	0.002915 (0.002573)	0.003255 (0.002767)
T	annual lump sum "tax" proposed in CV scenario (in \$10,000)	0.05602 (0.04579)	0.05661 (0.04770)
q	reported total number of salt water fishing trips to sites in Texas over the last year	17.40 (16.12)	15.78 (15.32)
I	indicator variable indicating that respondent would choose to keep fishing, despite tax T	0.8066 (0.3950)	0.7905 (0.4073)
E	Likert-scale subjective ex post assessment of current environmental quality at site	-	8.073 (2.177)

Table 2
Parameter Estimates for "Basic"
and "Environmental" Models

Parameter	Basic Model	Environmental Model
β_1 (z)	1.381 (1.080)	1.218 (0.6385)
β_2 (q)	0.1109 (6.635)	0.04825 (1.051)
β_3 ($z^2/2$)	0.6173 (1.526)	1.081 (1.106)
β_4 (zq)	0.008387 (1.990)	0.006219 (0.4773)
β_5 ($q^2/2$)	-0.008041 (-8.611)	-0.003755 (-1.383)
γ_1 (zE)	-	0.07805 (0.4148)
γ_2 (qE)	-	0.007991 (1.389)
γ_3 ($z^2E/2$)	-	-0.07346 (-0.6631)
γ_4 (zqE)	-	0.0003104 (0.1882)
γ_5 ($q^2E/2$)	-	-0.0005533 (-1.664)
v^a	15.13 (31.79)	15.15 (31.76)
ρ	0.2929 (4.631)	0.2975 (4.637)
Log L	-2339.80	-2334.69

^a See Cameron (1988a) for discussion of additional parameters.

10.22. The 5% critical value for a $\chi^2(5)$ distribution is 11.07 and the 10% critical value is 9.24. Thus, the improvement in the log-likelihood just misses being statistically significant at the 5% level for this small sample. Nevertheless, this difference seems large enough to warrant pursuing the implications of the fitted model. In any case, we can be confident that the statistical significance would improve with larger samples.

5. Implications of Fitted Parameter Estimates

In the earlier paper, several properties of the estimated models were recommended for attention. Here, the properties of the fitted utility function vary across levels of environmental quality, E . Consequently, we will evaluate the function at the subsample mean of E (8.0731) as well as at the maximum value of E (10) and at a lower benchmark value (6), which represents approximately one standard deviation below the mean. It is entirely possible to compute values for several interesting quantities for each individual in the sample. Here, however, we will focus on the "mean" consumer. Note that we have elected to use the mean values for income and fishing day expenses computed for the entire sample of 3366, on the presumption that the means in this sample are more typical of the mean for the population as a whole. (This is arbitrary; the results will be similar for the "mean" consume in the smaller subset.)

Table 3 summarizes several properties of the fitted utility function for the three benchmark levels of environmental quality. As expected, decreases in environmental quality substantially affect the value respondents place on access to this fishery. Value in this case is measured several ways. Compensating variation is the amount of additional income a respondent would require, if denied access to the resource, to make their utility level the same as that which could be achieved with the optimal level of access.

Table 3
Properties of the Fitted Utility Function

Property	E = 10	E = 8.0731	E = 6
Utility Function Parameters:			
β_1^*	1.998	1.848	1.686
β_2^*	0.1282	0.1128	0.09619
β_3^*	0.3467	0.4883	0.6406
β_4^*	0.009324	0.008726	0.008082
β_5^*	-0.009288	-0.008222	-0.007075
Function Saddle Point:			
z^*	-5.973	-3.954	-2.764
q^*	7.802	9.518	10.44
Demand Elasticity wrt			
price	-0.06034	-0.07351	-0.09211
income	0.1623	0.1610	0.1593
Compensating Variation for Complete Loss of Access			
	\$3742	\$2970	\$2283
Equivalent Variation for Complete Loss of Access			
	\$3741	\$2997	\$2314
EV for Access Restricted to a of Current Fitted Level, for $\alpha =$			
0.1	\$3018	\$2418	\$1867
0.2	2376	1903	1470
0.3	1814	1453	1122
0.4	1329	1064	823
0.5	921	737	570
0.6	588	471	364
0.7	330	265	205
0.8	147	117	91
0.9	37	29	23

Equivalent variation is the loss of income which would leave the respondent just as much worse off as would a denial of access. We also compute the equivalent variation for incomplete reductions in the level of access.

A visual depiction of the effect of environmental quality on the preferences of anglers (defined over fishing days and all other goods) is provided in Figure 1 for $E = 10$ (which can be considered "good" environmental quality) and for $E = 6$ ("relatively poor" environmental quality). As anticipated, indifference curves for $E = 10$ have considerably greater curvature, implying that anglers are less willing to trade off fishing days for other goods when the environmental quality is high. In contrast, with poorer environmental quality, the curvature is considerably less, implying that under these circumstances, anglers consider other goods to be relatively better substitutes for fishing days. For example, when $E = 6$, the same change in the relative price of a fishing day will lead to a larger decrease in the optimal number of days consumed than when $E = 10$.

In addition to the properties of the utility function and its corresponding Marshallian demand functions, we might be interested in calculating the derivatives of these Marshallian demand functions with respect to the level of the E variable. The Marshallian demand function for the model with heterogeneity is:

$$(2) \quad q = [(\beta_2 + \gamma_2 E) + (\beta_4 + \gamma_4 E)Y - (\beta_1 + \gamma_1 E)F - (\beta_3 + \gamma_3 E)FY] / [2(\beta_4 + \gamma_4 E)F - (\beta_3 + \gamma_3 E)F^2 - (\beta_5 + \gamma_5 E)]$$

Table 4 gives the utility maximizing number of fishing days demanded at the sample mean values of F and Y , as a function of the subjective level of environmental quality, E . Locally, there are only very slight differences in these fitted demands as a consequence of environmental changes.

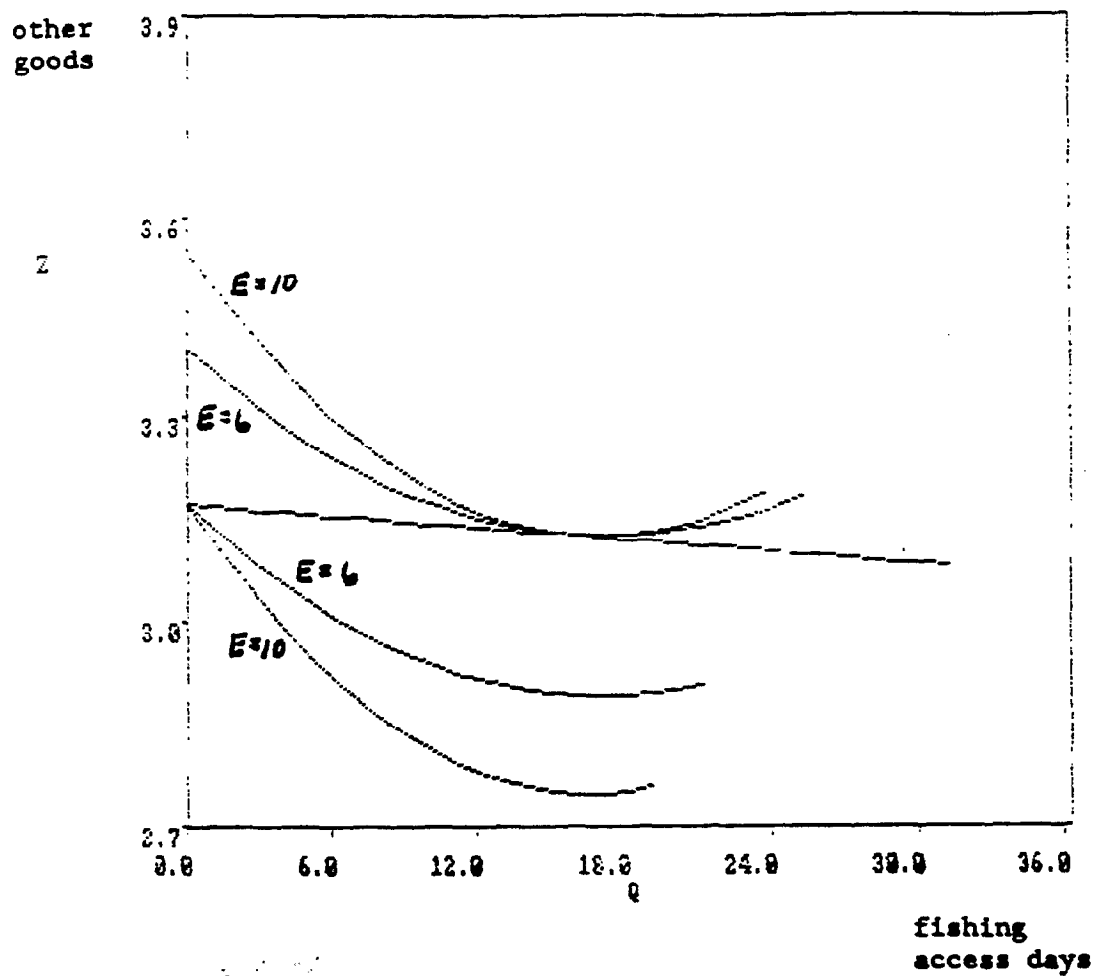


Figure 1. Fitted indifference curves for consumer with mean characteristics end $E = 10$; same for $E = 6$

Table 4

Optimal Demand, Derivatives and Elasticities
wrt Environmental Quality
(evaluated at mean Y and F, n = 3366)

E	q*	$\partial q / \partial E$	$(\partial q / \partial E)(E/q^*)$	EV for complete loss of access
1	14.72	0.2876	0.01953	\$1046
2	14.97	0.2260	0.03018	1264
3	15.18	0.1822	0.03601	1499
4	15.34	0.1501	0.03912	1751
5	15.48	0.1257	0.04060	2022
6	15.60	0.1068	0.04110	2314
7	15.70	0.09193	0.04100	2630
8	15.78	0.07993	0.04052	2971
9	15.86	0.07014	0.03981	3340
10	15.92	0.06204	0.03896	3741

We may be especially interested in the derivative of this fitted demand function with respect to E. It will depend not only on F and Y, but also on the level of E itself:

$$(3) \partial q / \partial E = \{ [2(\beta_4 + \gamma_4 E)F - (\beta_3 + \gamma_3 E) F^2 - (\beta_5 + \gamma_5 E)] [\gamma_2 + \gamma_4 Y - \gamma_1 F - \gamma_3 F Y] \\ - [(\beta_2 + \gamma_2 E) + (\beta_4 + \gamma_4 E)Y - (\beta_1 + \gamma_1 E)F - (\beta_3 + \gamma_3 E)FY] \\ [2 \gamma_4 F - \gamma_3 F^2 - \gamma_5] \} / [2(\beta_4 + \gamma_4 E)F - (\beta_3 + \gamma_3 E) F^2 - (\beta_5 + \gamma_5 E)]^2.$$

This formula is untidy, but can be readily computed. Table 4 gives the values of this derivative as well as the corresponding elasticity, $(\partial q / \partial E)(E/q)$, for the full range of integer values of E which are possible in the data.

A visual display of the effects of changes in E upon the configuration of the fitted inverse demand curve for an individual with mean Y and F is presented in Figure 2. Observe that, although the demand function can be highly non-linear in F, the fitted values of the parameters (for these data and in combination with the sample mean angler characteristics) yield demand functions which are almost linear. Each fitted demand curve passes through the value of F and the corresponding particular fitted value of q^* (for each E) for this representative consumer. Notice that variations in E, in the fitted model, have rather dramatic effects upon the implied choke price for access to the resource: the better the environmental quality, the higher the choke price.

The variation in the configuration of preferences, and the obvious shifts in the demand curves as a function of E imply that the social value of access to the fishery will depend upon the subjective level of environmental quality at fishing sites. To illustrate this sensitivity, we have computed the equivalent variation for a complete loss of access to the resource, as a function of E, for a representative consumer with sample mean levels of Y and

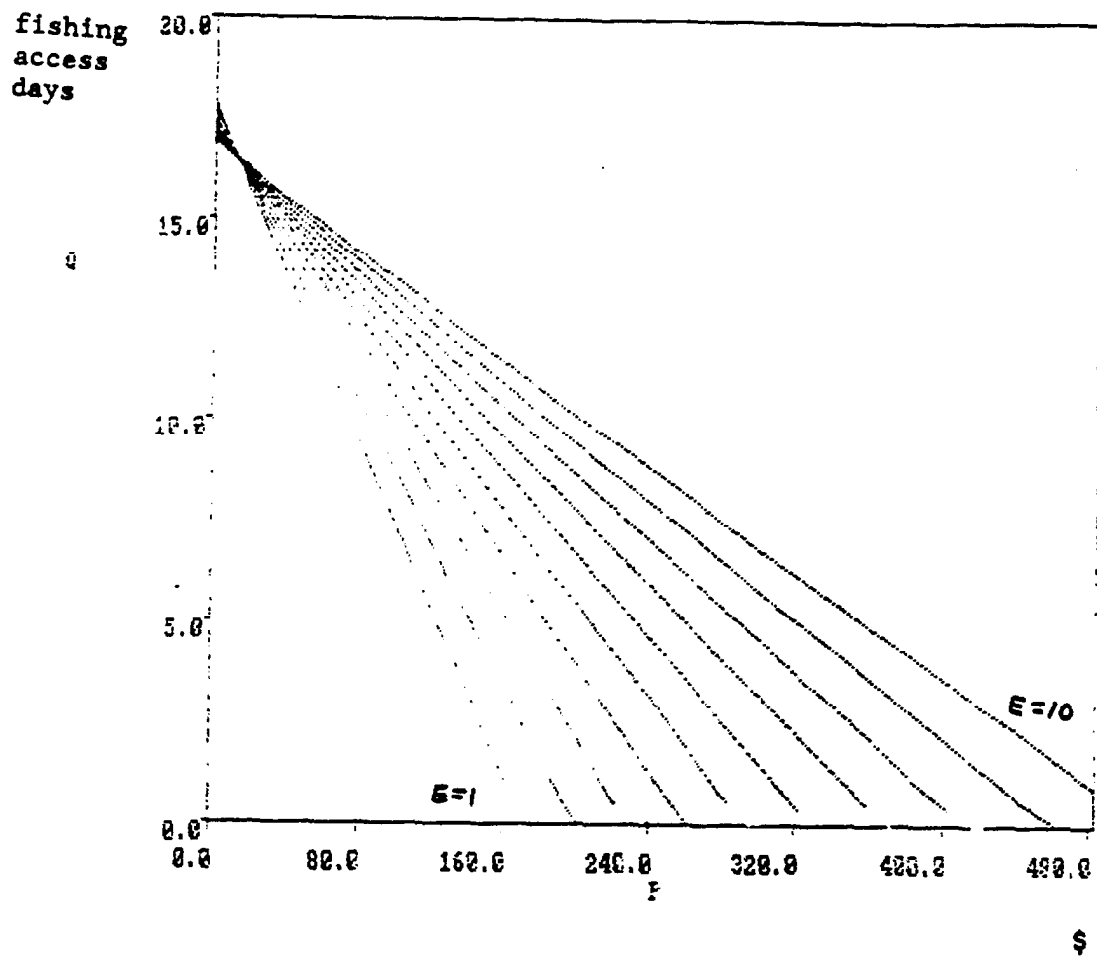


Figure 2. Effects of increasing subjective environmental quality on inverse demand curve for an angler with sample mean characteristics.

F. These equivalent variations are also given in Table 4. Bear in mind that the range of E from 6 to 10 accounts for approximately one standard deviation on either side of the mean value reported in the sample. The EV estimates in Table 4 suggest that for a typical angler, improving environmental quality from the "6" level to the "10" level would add approximately \$1400 to the annual value of access to the fishery (an increase of over 50%).

This value must be considered in relation to the actual distribution of E values in the sample. Tables 5 and 6 give the details of these responses. Almost 40% of the sample is completely satisfied with current environmental quality. This suggests an alternative "simulation" based on the fitted model. Instead of simply considering the mean angler, it is also possible to simulate changes in E for each individual angler in the sample. Under current conditions, the equivalent variation for a complete loss of access varies over the sample from \$648 to \$4235, with a mean of \$3037 and a standard deviation of \$778. If we take every respondent who reported a subjective environmental quality level of less than 10 and increase their value of E by one unit, the distribution of these fitted equivalent variation values can be expected to change. In fact, the new fitted values vary from \$839 to \$4238, with a mean of \$3253 and a standard deviation of \$715. Thus the increase in the mean of the equivalent variations, when we improve by one unit the experiences of those who were less than completely satisfied experience currently, is approximately \$216. If we could scale this up to the entire population, this represents an increase in the social value of the fishery of approximately 6.6%.

6. Subjective Environmental Qualities as a Function of Physical Measures

The subjective environmental quality question on the Texas Parks and Wildlife Survey elicits information about overall environmental quality. We

Table 5
Descriptive Statistics for E Variable

MOMENTS			
N	506		
MEAN	8.07312	SUM	4085
STD DEV	2.17742	VARIANCE	4.74118
SKEWNESS	-1.216	KURTOSIS	0.897612
QUANTILES (DEF=4)			
100% MAX	10	99%	10
75% Q3	10	95%	10
50% MED	9	90%	10
25% Q1	7	10%	5
0% MIN	1	5%	4
		1%	1
RANGE	9		
Q3-Q1	3		
MODE	10		

Table 6

Frequency Distribution of E Values

		FREQ	CUM. FREQ	PERCENT PERCENT	CUM.
1	]*	7	7	1.38	1.38
2	]*	7	14	1.38	2.77
3	]**	10	24	1.98	4.74
4	]***	11	35	2.17	6.92
5	]*****	46	81	9.09	16.01
6	]*****	25	106	4.94	20.95
7	]*****	41	147	8.10	29.05
8	]*****	93	240	18.38	47.43
9	]*****	81	321	16.01	63.44
10	]*****	185	506	36.56	100.00

----+----+----+----+----+----+----+----+----+----+----+
 20 40 60 80 100 120 140 160 180
 FREQUENCY

do not presently have access to typical or specific air quality measurements for different areas along the Texas Gulf Coast, but in the course of related research (Cameron, 1988b), we have attempted to determine how a variety of water quality measures are related to respondents' subjective assessments of environmental quality.

From a variety of auxiliary sources reported in Cameron (1988b), including the Texas Department of Water Resources, and the Resource Monitoring division of Texas Parks and Wildlife, we have obtained data on the characteristics of tens of thousands of water samples over the few years up to and including the time period of the valuation survey. Most of the water quality "parameters" have been averaged by month and by each of the eight major bay systems along the Texas Gulf Coast. A few are available only by bay system. (See the original document for details.)

Table 7 reproduces the results for E regressed on a variety of water quality parameters in an *ad hoc* specification. Not surprisingly, the relationship between the subjective environmental quality measure and "typical" water quality is quite weak. For this reason, we do not devote space in this paper to a discussion of the explanatory variables. The reader is referred to Cameron (1988b) for this information. Certainly, many more physical factors will affect perceptions than simply the few for which we have measurements. Attributes of the respondent can also be expected to have some impact upon the subjective assessments of environmental quality. Other regressions reported in the appendices of Cameron (1988b) examine the influence of socioeconomic variables on these responses. They also establish the presence of some seasonal and geographical variation.

Table 7

OLS Regression of "Ability to Enjoy Unpolluted
Natural Surroundings: on Measured Water Quality Variables

<hr/>			
F-TEST	4.247		
OBS	695		
<hr/>			
VARIABLE	PARAMETER ESTIMATE	STANDARD ERROR	T FOR HO: PARAMETER = 0
<hr/>			
INTERCEP	8.334	1.860	4.481
MTURB	0.001600	0.01016	0.158
MSAL	0.01851	0.01795	1.031
MDO	-0.2415	0.1387	-1.742
TRANSP	0.02034	0.01311	1.551
DISO	0.2204	0.1077	2.047
RESU	0.005304	0.006889	0.770
NH4	6.053	3.659	1.654
NITR	-2.236	1.155	-1.936
PHOS	2.357	1.700	1.386
CHLORA	-0.002728	0.02576	-0.106
LOSSIGN	-0.009637	0.02440	-0.395
OILGRS	-0.003734	0.001145	-3.261
CHROMB	0.02663	0.02361	1.128
<hr/>			

8. Conclusions

Clearly, there is good evidence that angler's value of the fishing experience is affected by their subjective assessment of environmental quality. For this small sample from the Texas survey, allowing for heterogeneous preferences which vary with environmental quality makes a statistically significant improvement in the econometric model at almost the 5% level. Despite the fact that we have lumped all other goods in the consumption bundle into a single composite, the fundamental regularity conditions for a utility-theoretic model are satisfied. Of course, all of the caveats mentioned in Cameron (1988a) and Cameron (1988b) also apply to this analysis, so the results must be interpreted with some caution.

Unambiguously, if anglers' *perceptions* of environmental quality can be improved, our model indicates that the social value of the resource will be increased (and vice versa, of course). What is clear, however, is that a better link must be forged between perceptions and actual physical quantities of pollutants (both air and water). We need to know just what it takes to raise someone's response from an 8 to a 9 on this type of Likert-scale question. This will require cooperation between physical and social scientists.

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